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Relativistic effects in proton-induced deuteron break-up at intermediate energies with forward emission of a fast proton pair

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abstract Recent data on the reaction $pd \to (pp)n$ with a fast forward $pp$ pair with very small excitation energy is analyzed within a covariant approach based on the Bethe-Salpeter formalism. It is demonstrated that the minimum non-relativistic amplitude is completely masked by relativistic effects, such as Lorentz boost and the negative-energy $P$ components in the ${}^1S_0$ Bethe-Salpeter amplitude of the $pp$ pair.

The investigation of hadronic processes at high energies, such as reactions of protons scattering off deuterons, provides a refinement of information about strong interaction at short distances. Nowadays, large research programs of experimental studies of processes with polarized particles are in progress. Important are setups with deuteron targets or beams kox0,preliminar,cosyproposal, since the deuteron serves as a unique source of information on the neutron properties at high transferred momenta, the knowledge of which allows, e.g. to check a number of QCD predictions and sum rules. Additionally, the hadron-deuteron processes can be considered as complementary tool in investigating short-distance phenomena and also as a source of information unavailable in electromagnetic reactions. Of interest is the study of nucleon resonances, checking non-relativistic effective models, meson-nucleon theory, $NN$ potentials etc. In this line is the investigation of the deuteron break-up reaction with a fast $pp$ pair at low excitation energy, proposed in cosyproposal and with first results reported in preprint$_k omarov$.

One motivation for the experiment preprint$_k omarov was the possibility to investigate the off-mass shell effects in NN inter$
$relativistic {}^1S_0$ wave function of the two outgoing protons, provided the non-relativistic picture holds and the off-mass shell effects can be neglected. The recent data preprint$_k omarov exhibits, however, a completely different behavior :$
$the cross section is smoothly decreasing; there is no signo f a pronounced minimum. Accounting for corrections beyond the one-$
$nucleon exchange mechanism improve the agreement with data, however a quantitative description have not achieved preprint$_k or$

It is clear, that the non-relativistic treatment of the process becomes inadequate because of the high virtuality of the proton in the deuteron at the considered kinematics. More realistic approaches which take into account relativistic effects and the off-mass shellness of the interacting nucleons are desired. The Bethe-Salpeter (BS) formalism can serve as an appropriate approach to the problem because the off-mass shellness of the nucleons is an intrinsic feature of the BS equation. Moreover, the solution of the BS equation, being manifestly covariant, incorporate genuine relativistic effects (Lorenz boosts, negative-energy components etc.), hardly accessible within the Schrödinger formalism. In the present note we use the BS approach to analyze the data preprint$_k omarov on deuteron break-up with the emission of a fast forward$ ppp$air foonote_1. We pay particular attention on r$
$boson exchange kernel solution. The final state interaction of the two protons is treated also within the BS formalism by solving th$
$iteration approximation our few body, nashi. In doing so, a big deal of off-mass shell effects and relativistic corrections are take$

Let us consider the process equation $\mathrm{p} + d = (p_1 p_2)(0^0) + n(180^0) reaction$